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Effects of Late Gestation Supplementation and Creep Feeding on Spring Calving Beef Cows in the Nebraska Sandhills

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EFFECTS OF LATE GESTATION SUPPLEMENTATION AND CREEP FEEDING ON SPRING CALVING BEEF COWS IN THE NEBRASKA SANDHILLS

by

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EFFECTS OF LATE GESTATION SUPPLEMENTATION AND CREEP FEEDING ON SPRING CALVING BEEF COWS IN THE NEBRASKA SANDHILLS

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The objectives of this research were to 1) evaluate the effects of late gestation supplementation, synchronization and creep feeding on cow and calf production traits 2) evaluate the pooled effects of 5 studies involving late gestation supplementation on cow and calf traits. Experiment 1 was a three year study conducted on 8 pastures at the Gudmundsen Sandhills Laboratory. Cows were assigned to 1 of 4 late-gestation supplementation treatments, postpartum progestin or control, and 1 of 2 creep feed treatments to make up a 4 x 2 x 2 factorial arrangement. Calves were followed through to slaughter.

Experiment 2 involved 5 studies all conducted at the UNL Gudmundsen Sandhills Laboratory. Studies were pooled based on similar treatments of late gestation supplementation on dormant upland pasture or meadow and different weaning periods. Cow and calf data was analyzed for various traits.

Within Experiment 1 all three levels of supplementation increased cow BW and BCS, while the non-supplemented decreased in both. Supplementation treatments did not affect reproductive efficiency such as calving date, calving rate, weaning rate or pregnancy rate. Synchronization had similar results as there were no effects on reproductive measures or calf BW. Supplementation to cows had no effect on calf production traits through slaughter. Creep feeding calves significantly increased calf BW at weaning, yield grade and 12th rib fat. However on a cost/ benefit analysis creep feeding under these conditions added no value on profitability.

Different results were achieved with the larger data set of late gestation supplementation. The pooled analysis demonstrated significant effects from supplementation on cow pregnancy rate, adjusted calf BW at weaning but no effect on carcass characteristics. March systems had a higher average pair feed cost but lower cow replacement cost compared to May. The March calving system had higher average net returns based on 9 yrs of market data compared to a May calving system. These studies indicate the effect and importance of late gestation supplementation on cow and calf productivity in a spring calving herd. Cow-calf producers should carefully consider calving system utilization based on their unique production goals.
Key words: calving system, supplementation, economics

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CHAPTER I: LITERATURE REVIEW

INTRODUCTION

Beef cattle producers base nutritional decisions on what is profitable and the animal's nutrient requirements. It can be a complex system that involves environmental and management decisions. Forage availability and quality, cow condition, production goals, amount of labor, and cost influence nutrient requirements and management decisions. Extending the grazing season in a spring calving herd to include dormant pasture decreases production cost (Adams et al., 1994). Research has determined supplemental RDP is necessary to maintain BCS of gestating cows grazing dormant winter range in the Nebraska Sandhills (Stalker et al., 2007). Grazing dormant pasture can minimize production costs significantly but can also affect cow maintenance, fetal development, and calf performance. Supplemental RDP is necessary for gestating beef cows to maintain BCS throughout dormant pasture grazing. Maintaining cow BCS includes providing the necessary nutrients for fetal growth and development, as these biological factors are intertwined. Amidst feeding supplemental RDP, it is common to overfeed protein, thus reducing profitability of the production system. This can be prevented by 4 key approaches: introducing dams to dormant grazing at an ideal BCS, understanding nutrient requirements of the cow and calf, understanding what nutrients dormant pasture is lacking, and knowing how much feed needs to be purchased. All of these aspects can impact future productivity and profitability. Managing to improve nutrient utilization is key to any production system, regardless of season. With multiple studies done on late gestation supplementation it is important not to forget about the effects of nutrition during gestation. This being said, late gestation supplementation can be considered the most important period when regarding the fetus and cow (Du et al., 2010). During this period muscle and adipose tissue growth occur. Undernutrition affect progeny carcass characteristics. On the cow side, undernutrition makes it harder for the cow achieve maintenance body condition score. Finding a nutritional balance that enhances production traits without decreasing profit through increased costs is vital.

PRODUCTION ENVIRONMENTS AND FETAL PROGRAMMING

Matching nutrient requirements with feed resources available may optimize production efficiency. Forage systems and livestock production are intertwined. Depending on the calving season, during the production cycle for most beef producers, rangeland forage is dormant during times of significant biological energy demand (gestation, parturition, and lactation). If dietary intake does not meet nutrient requirements, body tissue reserves (both lean and adipose) will be mobilized to balance the deficiency. In forage-based production systems, forage quality and quantity is dynamic and dependent on environmental conditions (i.e. precipitation timing and amount) and management. For instance, Nebraska Sandhills upland native range will range from 6.2% to 12.4% CP with corresponding TDN values of 49.9% to 64.8% during the year (Mulliniks et al., 2019). Diverse production systems utilizing pastures, harvested forages, and crop residues have evolved in different regions of the U.S. in response to soil and climate, competing requirements for land and water resources, and the relative cost and availability of feed grains (Reid et al., 1983). Depending on season of calving, gestating cows often graze in production systems that do not meet their nutrient requirements. Consequently, understanding how different environments and forage systems impact the entire production system from conception to slaughter.

GESTATIONAL SUPPLEMENTATION

Dormant Grazing Season Nutrient Requirements

Cows have different nutrient requirements depending on their physiological stage of production, the time of year, and the feeding program. Nutritional management may not only affect maintenance, growth, or production in lactating or gestating cows, but it can also influence fetal growth and subsequent postnatal performance (Stalker et al., 2006). Protein supplementation can increase cow BW gain, BCS, and during certain times, forage intake and digestibility. (Clanton and Zimmerman, 1970; Beaty et al., 1993; Pruitt et al., 1993; Kartchner, 1981). During the dormant season, forage in the Nebraska Sandhills is generally below 7% CP (Mulliniks et al., 2019). Karges (1990) demonstrated RUP protein was not limiting in gestating beef cows fed native winter range, which can indicate MP requirement can be met by microbial and escape protein in the forage. These results can also be influenced by calving date. Mulliniks (2019) demonstrated that digestibility would be expected to decrease because of the time of year with weathering and environmental factors which also impact the stocking rates of winter pastures knowing that cows will require more AUM to meet requirements even with protein supplementation.

Protein RDP requirements of a cow in late gestation supplementation grazing native winter Sandhills range can be between 340 and 430 g/d or approximately 4% of OM intake. Depending on forage quality, intake and cow BW the supplemental RDP needed is between 61.7 and 140 g/d and RDP requirement is 7.1% of digestible OM. (Hollingsworth-Jenkins et al., 1996) However, Karges (1990) estimated an average cow size of 523 kg consuming 47% TDN forage at 1.9% of BW required 611g of RDP, with 271 g supplied by the forage.

Requirement will differ depending on the system but ultimately if the cow BW was maintained during the time period of lower quality forage, energy and escape protein were not limiting (Hollingsworth-Jenkins et al., 1996). Ruminally degradable protein supplied by dormant forage varies year to year and across production systems making it important to have a good estimate of RDP to estimate the correct supplement strategy. Digestibility of CP in forage is high (Haugen et al., 2006), but as mentioned, once forage CP drops below 7% it is important to provide or increase supplement simply because RDP is driven by fermentable energy. Supplementing RDP to beef cattle consuming low quality forage diets (below 7% CP) will increase forage utilization by increasing intake and digestibility (Church and Santos, 1981; Lee et al., 1985; Köster et al., 1996), thus in turn improving animal performance. Added protein introduces a source of ruminally available N, that along with fermentable OM by certain microbes in the rumen, synthesizes nitrogenous compounds and aids in growth of these microbes. (Wickersham et al., 2008)

Another important factor to be considered when looking at the nutrient requirements of a gestating cow on dormant range is how often protein supplementation is provided. Beaty (1994) noted within this specific study when dealing with frequency of supplement being feed reducing supplementation frequency also decreased forage intake but when frequency was increased cow BW and calf weaning BW gains increased. Even with the performance differences not being large, daily supplementation did maximize forage intake and cow performance.

Undernutrition

Beef herds are managed in conditions varying from confinement cow-calf production units to more common grazing systems. Forage quality is often poor or low in nutrients in dry and winter seasons, making it inadequate nutrition for growing, gestating, and lactating herbivores without protein and energy supplements (Lippke, 1980; Hoaglund et al., 1992; Huston et al., 1993; Fontaneli et al., 2005). In larger production systems with over 200 cattle, there are times where little or no supplement is provided for grazing ruminants (Fotaneli et al., 2005). This can suggest that fetal undernutrition frequently occurs in animal agriculture, leading to reduced fetal growth. Undernutrition of gestating cows grazing dormant winter range can cause cows to mobilize not only body fat for energy, but it may also cause cows to mobilize protein tissue. In response, undernutrition during gestation causes suboptimal conditions in the maternal uterine environment, which can depress progeny performance (Wu et al., 2006)

As an example Thomas and Kott (1995) reported that without any supplement, nutrient uptake of grazing ewes in the western United States is often less than 50% of the National Research Council recommendations (NRC, 1985). Unsupplemented grazing ewes lost a significant amount of BW during pregnancy, and their health, fetal growth, and lactation performance were seriously compromised (Thomas and Kott, 1995). Nutrient restriction of adult ewes (Redmer et al., 2004) and overnutrition of adolescent ewes during pregnancy (Redmer et al., 2005) reduced placental proliferation in the fetal trophectoderm and placental expression of angiogenic factors. In the same overfed adolescent ewes, Wallace et al (2002) found these changes at mid-gestation may underlie the attenuated uteroplacental blood flows that characterize late pregnancy (approximately d 130) in these rapidly growing animals.

The influence of maternal nutrition on fetal development can be complicated by an undernourished fetus in well-fed dams because placental size or function is inadequate to meet fetal demands (NRC, 2000). However, the fetus may have protection against prepartum protein undernutrition by the dam mobilizing maternal body reserves (Martin et al., 1997). Even when the dam is undernourished, the maternal and placental systems may compensate to minimize fetal malnutrition (Bassett et al., 1986, 1991). This also demonstrated that proper nutritional management during gestation is still a priority to improve subsequent progeny performance and health. Timing of nutritional restriction can also affect a developing fetus. Due to minimal nutrient requirements of the fetus during early gestation in many environments, nutrition restriction during this time was thought to have little to minimal negative impact on fetal growth (Wu et al., 2006). However, during fetal development from mid- to late gestation, critical events are required for normal conceptus development occur, including fetal organogenesis and placental development (Funston et al., 2010) Increased rate of growth of the developing fetus during mid- to late gestation places more metabolic demand on the cow. Since growth predominates during the latter half of gestation, and is of a lower priority for nutrient partitioning in the fetus, sub-optimal maternal nutrition at this stage can negatively affect fetal growth and muscle development.

Environmental conditions and long-term management can impact how livestock respond to environmental stress and nutrient restriction. Comparing long-term (adapted over 30 years) management in farm sheep flocks, maternal undernutrition in gestating ewes from nutrient-restricted environments did not affect fetal growth, plasma glucose concentrations, (Vonnahme et al., 2006) or amino acid concentrations (Jobgen et al., 2008). These studies imply the dam and fetus may have the ability to adjust against nutrient restrictions when livestock are managed long-term in their environment. Research with fish gives insight into long-term management in highly variable, harsh environments and how they cope with those stressors. Transgenerational acclimation in fish (Donelson et al., 2012) illustrates how single generation studies may underestimate the potential of a species to cope and adapt. Therefore, in many beef production settings, the developmental programming response in nutrient-restricted environments may positively impact developing animals better adapted and resilient in those environmental conditions.

Overnutrition

Overnutrition is defined as increased intake in energy, protein, or both above nutrient requirements. Gestational overfeeding of livestock and companion animals occurs when excess amounts of protein or energy (particularly concentrates but could include feed above 25% protein, 70% TDN) are provided to dams before breeding or during pregnancy (Han et al., 2000; Luther et al., 2005). Maternal overnutrition prior to breeding or during early pregnancy often results in increased porcine embryo and fetal mortality (Ashworth, 1991; Einarson and Rojkittikhun, 1993). Other studies have shown just like underfeeding, overfeeding once pregnancy is established retards fetal growth in pigs (Cole, 1990) and adolescent sheep (Wallace et al., 2004). It has been shown feeding mares to obesity before or after mating can reduce fetal growth and cause fetal death

(Pugh, 1993). Increased feed intake by sows during all or part of gestation negatively affects feed intake during lactation. (Han et al., 2000).

TRANSFER OF NUTRIENTS FROM COW TO CALF

The placenta transports nutrients, respiratory gases, and the products of metabolism between maternal and fetal circulation. Placental growth, which includes vascular growth, is crucial for fetal growth and development (Gootwine, 2004; Reynolds et al., 2005). Elevated expression of placental anabolic proteins can be associated with enhanced fetal growth in sheep (Gootwine, 2004). Looking at normal pregnancy, uterine and placental blood flows increase throughout gestation to meet the metabolic needs of the growing conceptus (Reynolds et al., 2005). Umbilical blood flow also increases markedly during the late gestation period of most livestock to satisfy the metabolic needs of the rapidly growing fetus. (Ford, 1995; Pére and Etienne, 2000). What is shown from this evidence is that blood flow influences nutrient availability for fetal growth and development.

Pertaining to increased uterine and placental blood flows (Ford, 1995), placental angiogenesis increases notably from the first to the second trimester of gestation and continues to increase further during late gestation (Reynolds and Redmer, 2001). When looking at the blood concentrations of metabolites in the uterine artery and vein as well as the umbilical vein and artery can be regulated by 1) the activities and amounts of nutrient transporters on the plasma membranes of cells of the uteroplacental unit, 2) the amounts of the substances entering circulation from dietary and endogenous sources, and 3) rates of oxidation of the substances. There is evidence reductions in placental growth and presumably placental vascularization are associated with decreased placental transport of

O_2 and nutrients from mother to fetus in comprised ovine pregnancies (Wallace et al., 2002,).

FETAL DEVELOPMENT

Early Gestation (0 to 3 mo)

Primary formation of skeletal muscle development starts during the embryonic stage. The primary myofibers form during the initial stage of embryonic development. Secondary myofibers will form during the second wave of myogenesis in the fetal stage. All this growth accounts for the majority of skeletal muscle fibers (Du et al., 2010). No new muscle fibers are formed after birth; postnatal muscle growth is caused by an in increase in muscle fiber size because at this stage new muscle fibers are not being formed (Stickland, 1978; Karunaratne et al., 2005). Knowing skeletal muscle formation happens early in gestation, muscle growth is vulnerable to many setbacks including nutrient deficiency and also overnutrition (Zhu et al., 2004). This being said, skeletal muscle can often be neglected when looking at the first trimester of gestation since organ development is crucial to health and life of the offspring. Although the growth performance of offspring may not always be affected, Long et al. (2010) saw lung and trachea weights of males born to dams only meeting 55% of their nutrient requirements were less.

Mid Gestation (3 to 6 mo)

The amount of intramuscular fat or marbling is determined by the size and number of intramuscular adipocytes. A small portion of these cells in fetal skeletal muscle are made into adipocytes, to form sites for intramuscular fat accumulation that produce marbling in offspring (Tong et al., 2009). This process is initiated around mid gestation in ruminant animals (Feve, 2005; Gnanalingham et al., 2005; Muhlhausler et al., 2007). Maternal nutritional management enhances the number of mesenchymal cells committed to adipogenesis, which increases the number of intramuscular adipocytes and thus marbling. This research demonstrates from mid gestation forward, carcass characteristics can be significantly affected.

Late Gestation (6 to 9 mo)

Late gestation has been shown to have the most effects on postnatal calf growth. This is mainly because major portions of the beef cattle muscle and adipose tissue form during late gestation (Du et al., 2010). As mentioned in early and mid gestation, there can be no net increase in the number of existing muscle fibers. This translates to the fact if nutrient restriction occurs during late gestation, muscle fiber numbers will decrease (Zhu et al., 2004), possibly causing calf growth performance following birth to be compromised.

Overall Development Summary

Starting with DNA methylation, genes of parents, epigenetic state and maternal maturity there are many factors to be at least considered with fetal growth. Environmental issues and transferring of nutrients for placental growth are also included in these factors. (Wu et al., 2006). Evidence suggests maternal or fetal nutritional status can alter the epigenetic state of the fetal genome and gene expression of imprinted genes (e.g, Igf2 and H19), where DNA methylation and proteins plays a crucial role (Doherty et al., 2000).

Most fetal development research for spring calving herds occurs during the last trimester of gestation. This is an important period of growth for the fetus and needs to be considered since most often cows are on a lower plain of nutrition during the dormant season of grazing. This being said, fetal development is not only dealing with nutrition. Growth and development of the fetus is a biological event influenced by genetic, epigenetic, maternal maturity as well as environmental and other factors (Redmer et al., 2004; Gootwine, 2005). These factors affect the size and functional capacity of the placenta, uteroplacental transfer of nutrients, oxygen from mother to fetus, conceptus nutrient availability, the fetal endocrine milieu and metabolic pathways (Bell and Ehrhardt, 2002; Fowden et al. 2005; Reynolds et al., 2005). Uterine capacity is defined as the physiological and biochemical limitations imposed on conceptus growth and development by the uterus (Bazer et al., 1969a, 1969b). Maternal nutrition and its effect on fetal growth have been demonstrated by studies that looked at embryo transfer and altered maternal nutrient intake. (Dickinson et al., 1962; Ferrell, 1991; Allen et al., 2002; Redmer et al., 2004). Available evidence indicates all placental mammals are sensitive to direct and indirect effects of maternal nutrition at all stages between oocyte maturation and birth (Robinson et al., 1999; Rehfeldt et al., 2004; Ferguson, 2005).

Evidence suggests the placental or fetal growth trajectory is vulnerable to maternal undernutrition or overnutrition throughout gestation but it can be argued the most profound effects occur when nutritional insults are applied during the period where rapid placental development is the highest (Wu et al., 2006).

FETAL PROGRAMMING IMPACT

Impact of Gestational Nutrition on Cow Performance

Extending the grazing season to include dormant pasture decreases production costs (Adams et al., 1994). During certain times in the production cycle, nutrient and forage availability may not meet cow requirements in some environments. Under these conditions, energy intake is reduced, possibly leading to a negative energy balance. Research has determined supplemental RDP is necessary maintain BCS of gestating cows grazing winter range in the Nebraska Sandhills (Stalker et al., 2007). Supplementing protein on winter range increases cow BW gain and BCS (Clanton and Zimmerman, 1970; Beaty et al., 1994 Pruitt et al., 1993) and at times forage intake and digestibility (Kartchner, 1981). Supplemental RDP also minimizes the body tissue mobilized to meet maintenance and production requirements. Periods of insufficient nutrient intake are often followed by compensatory gain, which may have limited impact on a breeding animal (Freetly et al., 2008,). Research has indicated management can bring about moderate stages of feed restriction and realimentation during periods of poor nutrient availability to improve nutrient utilization (Freetly and Nienaber., 1998). For instance, in a 7-yr study, Mulliniks (2016) reported overall pregnancy rates were greater in cows either losing or maintaining BW during late gestation compared with cows gaining weight. Although weight change differences were not reported up to and through breeding, this improved reproductive performance may be attributed to a decrease in nutrient requirements in cows losing weight during late gestation and an overall increase in nutrient utilization postpartum.

Multiple studies have resulted in no differences in reproductive efficiency between supplementation and no supplementation during late gestation. Even with the increase of cow BW and BCS during winter supplementation, this did not affect reproductive efficiency such as calving date, calving rate, weaning rate or pregnancy rate assuming all cows were maintained in adequate BCS post dormant grazing period

(Broadhead et al., 201; Stalker et al., 2007)6. These results indicate prepartum nutrition in mature cows may have less of a role in subsequent reproductive performance and more influence on fetal growth and subsequent progeny performance.

Protein supplementation has been shown to increase cow BW gain while grazing low-quality dormant forage (Clanton et al., 1970). However, results from previous research evaluating prepartum supplementation effects on cow performance (Table 1) has varied greatly and been largely inconclusive (Stalker et al., 2006; Larson et al., 2009; Mulliniks et al., 2012). This may be due to differences in amount and type of protein fed, total dietary protein intake, environmental conditions, nutrient use efficiency of the cowherd, and previous long-term management of the cows.

Table 1. Effect of no supplementation (NS) vs. prepartum protein supplementation (SUP) while grazing dormant, low-quality native range on cow performance and subsequent reproductive performance.

	Stalker et al. 2006		Larson et al. 2009		Mulliniks et al. 2012	
Item	NS	SUP	NS	SUP	NS	SUP
BW change, kg						
Prepartum	-29[a]	1[b]	--	--	-14[a]	2[b]
Postpartum	14	12	--	--	--	--
BCS change						
Prepartum	-0.65[a]	-0.10[b]	--	--	-0.5[a]	0.0[b]
Postpartum	0.30	0.25	--	--	--	--
Calving date, d	85	88	89	83	--	--
Calved in first 21 d, %	71	70	62	83	--	--
Pregnancy rate, %	90	93	94	96	94	94

[a,b]Means within a study with different superscripts differ ($P < 0.05$).

Impact of Gestational Nutrition on Heifer Progeny Performance

Data from 3 Nebraska studies evaluating how prepartum nutrition affected heifer progeny performance are reported in Table 2. Maternal nutrition may influence subsequent heifer lifetime productivity in the cowherd. In addition, nutritional management as early as mid-gestation can impact organ development. In an early to mid-gestation study (Long et al.,2012) cows were fed either 70 or 100% of their nutrient requirements from d 45 to 185 of gestation and then all cows were fed to nutrient requirements from d 185 of gestation until parturition. Although progeny birth and weaning BW were similar, heifers born to cows fed at 70% did have smaller ovaries and luteal tissue. This indicates mid-gestation nutrition can affect future reproductive performance of heifer progeny, and in the Nebraska Sandhills, May-calving cows may experience nutrient restriction during mid-gestation. Lansford (2018) evaluated progeny performance from cows grazing either native range or sub-irrigated meadow with and without protein supplementation during mid-gestation. Regardless of grazing treatment, protein supplementation during mid-gestation increased heifer progeny 205-day adjusted weaning BW compared with heifers from non-supplemented dams. Although, protein supplementation during mid-gestation increased heifer progeny weaning weight, heifer pregnancy rates and timing of conception were not influenced by dam supplementation.

Warner (2011) reported no differences in pregnancy rates for heifers from dams grazing corn residue during late gestation and receiving protein supplement compared with dams grazing corn residue and receiving no supplement. Similarly, Funston (2010) reported protein supplementation to cows grazing corn residue during late gestation did not affect subsequent heifer fertility. However in the same study, there was a tendency for increased pregnancy rates for heifers born to cows supplemented on winter range compared with heifers from non-supplemented cows on winter range. Corah (1975) reported age at puberty of heifer calves from energy-restricted primiparous dams was increased 19 days; subsequent pregnancy rate was not measured. However, dam nutrition within this study did not affect heifer birth date or weight. Protein supplementation during late gestation tended to increase subsequent weaning BW of heifer calves and increased the adjusted 205-day weight (Martin et al., 2007). In addition, prebreeding and pregnancy diagnosis BW were greater for heifers from protein-supplemented dams than heifers from un-supplemented dams. Yet, ADG from weaning to the first breeding season for heifers from yr 2 and 3 in the Martin (2007) study was not affected by dam treatment.

A study by Cushman (2014) examined how nutrient restriction to mature cows during the second and third trimester affected daughter growth and reproductive performance. These authors reported no negative impact on growth rates, age at puberty, or antral follicle counts on heifer progeny. However, Martin (2007) reported a 28% increase in percentage of heifers calving in the first 21 d of the calving season from protein-supplemented dams compared with non-supplemented dams. In contrast, Funston (2010) and Lansford (2018) reported no difference in the proportion of heifers calving in the first 21 days. In a long-term retrospective study, Beard (2019) determined how precipitation level during key fetal development periods impacted progeny performance. Although drought conditions resulted in decreased heifer BW at birth and weaning, heifer progeny experiencing drought in utero had increased lifetime retention and productivity in arid rangelands. This increased retention may have been due to offspring experiencing nutrient restriction in utero having an increased adaptive capacity to the environmental stressors in limited nutrient environments. Furthermore, increasing nutrient input during key physiological periods may cause progeny to require a greater level of nutrients to be reproductively competent in more harsh environments.

Table 2. Effect of no supplementation (NS) vs. prepartum protein supplementation (SUP) to dams while grazing dormant, low-quality native range on heifer progeny performance.

	Martin et al., 2007		Funston et al. 2010		Lansford 2018	
Item	NS	SUP	NS	SUP	NS	SUP
Birth weight, kg	35	36	35	35	32	32
Adjusted 205-day weight	218[a]	226[b]	213	217	187[a]	194[b]
Age at puberty, day	334	339	366	352	--	--
Puberty status, %	--	--	--	--	75	75
Prebreeding weight, kg	266	276	317	323	316	317
Pregnancy diagnosis weight, kg	386	400	364	368	399	408
Pregnant, %	80[a]	93[b]	80	90	82	86
Calved in first 21 d, %	49[a]	77[b]	85	77	76	78

[a,b]Means within a study with different superscripts differ ($P < 0.05$).

Impact of Gestational Nutrition on Steer Progeny Performance

Data from 4 late-gestation studies evaluating how dam protein supplementation influenced steer weaning and post-weaning performance are reported in Table 3. In the Nebraska Sandhills, Lansford (2018) illustrated protein supplementation during mid-gestation on dormant sub-irrigated meadow or native upland range did not impact calf growth from birth through weaning. In addition, mid-gestation protein supplementation did not influence feedlot ADG, HCW, 12th rib fat thickness, or yield grade. Conversely, Underwood et al. (2010) studied the growth performance of steers born from dams that grazed either low-quality, native range (6% CP) or high-quality, irrigated pasture (11% CP) during mid-gestation. Weaning and carcass weights were reduced for steers from cows that grazed low-quality native range pastures compared with steers from dams that grazed higher quality irrigated pastures during mid-gestation. Munoz et al. (2008) evaluated how nutrient restriction during early or mid-pregnancy affected lamb performance from birth to weaning. These authors fed diets from conception to d 39 of gestation deficient (60%), adequate (100%), or in excess (200%) of predicted metabolizable energy for maintenance. From d 40 to 90 of gestation, they fed diets deficient (80%) or in excess (140%) of their predicted ME for maintenance. All ewes were fed at maintenance levels after d 90 of gestation. These researchers reported lambs from ewes fed a restricted diet in early gestation were born heavier, had higher IgG levels 24 h after birth, and had a lower mortality rate at weaning than lambs from the adequate or excessive dams.

Stalker (2006) investigated how pre- and postpartum nutrition affected calf growth and feedlot performance. Cows grazing native range during late gestation received either no supplement or a 42% CP supplement at 0.45 kg/day. Calves from supplemented dams gained more and were heavier at weaning compared with calves from non-supplemented cows. However, feedlot performance (ADG, feed efficiency, and DMI) was similar for both groups of steers, concluding supplemental feeding to the dam may not influence steer post-weaning feedlot performance. In a second study conducted by Stalker (2007), steers from supplemented dams had greater pre- and post-weaning gains compared with steers from non-supplemented dams. However, Larson (2009) demonstrated dam nutrition did affect calf birth weight and early gains and this difference persisted through weaning and slaughter. Steers from supplemented dams tended to gain more after placement in the feedlot compared with steers from non-supplemented dams. However, even with the tendency towards greater ADG and feed consumption on a per pen basis, overall gain efficiency was not different, which agrees with Stalker (2006). Studies reporting an increase in weaning BW from dam supplementation have illustrated an increase in BW that continues to the HCW (Larson et al., 2009; Stalker et al., 2007) Other studies have shown no differences in feedlot performance or carcass characteristics between progeny from supplemented and non-supplemented dams during late gestation (Stalker et al., 2006; Mulliniks et al., 2012; Mulliniks, 2013; Broadhead, 2016). Reasons for these varied results could be due to differences in herd management, environmental or weather conditions, genetic makeup of the cowherd, metabolic efficiency, and adaptability to cope with environmental factors. Based on what was discussed these results could differ based on differences in nutrient content of forages, length of feeding and type of supplement.

Table 3

Effect of no supplementation (NS) vs. prepartum protein supplementation (SUP) to dams while grazing dormant, low-quality native range on steer progeny performance.

	Stalker et al. 2007		Stalker et al. 2006		Larson et al. 2009		Mulliniks et al. 2012	
Item	NS	SUP	NS	SUP	NS	SUP	NS	SUP
Weaning BW, kg	200[a]	210[b]	211[a]	218[b]	223[a]	241[b]	253	253
DMI, kg/d	11.15[a]	12.05[b]	8.48	8.53	8.94	9.19	--	--
ADG, kg/d	1.60	1.68	1.57	1.56	1.66	1.70	1.38	1.46
F:G	6.97	7.19	5.41	5.46	5.37	5.38	--	--
HCW, kg	347[a]	365[b]	363	369	364[a]	372[b]	322	323
Choice, %	--	--	85	96	71	86	--	--
Marbling score	449	461	467	479	444[a]	493[b]	487	487

[a,b]Means within a study with different superscripts differ ($P < 0.05$).

IMPACT OF GESTATIONAL NUTRITION ON PROGENY HEALTH

In addition to influencing calf growth, undernutrition of gestating cows has been illustrated to reduced passive immunity (Blecha et al., 1981; Bellows et al., 1978). Blecha (1981) reviewed how prepartum protein restriction in the last 100 d of gestation affected immunoglobulin (IgG) content in the blood and absorption of colostral whey and IgG by the neonatal calf. These authors found no difference in immunoglobulin concentrations in the serum or colostrum of the cow when fed different levels of protein. However, IgG absorption by the calf after birth increased as protein levels increased in the dam diet. This indicates calves from cows consuming low levels of protein might have decreased passive immunity transfer. Hough (1990) also looked at how nutritional restriction during late gestation affected passive immunity in beef cattle. In this study, the restricted diet was 57% of NRC (2000) requirements and the control diet was 100% of the NRC requirements for both protein and energy. It should be noted in production settings, livestock may never experience as severe a restriction as Hough(1990), nevertheless, serum IgG concentrations were not affected by prepartum nutritional management, suggesting calf ability to absorb IgG was not altered by maternal nutrient restriction.

Calf health is directly correlated to feedlot performance, carcass value, and profitability. Several studies have linked prepartum nutrition to subsequent calf health post-weaning. Studies from New Mexico indicate prepartum supplementation strategy may not influence calf weaning weight or feedlot performance (Mulliniks et al., 2012; Muliniks et al., 2013). However, these studies do reveal calves born from dams provided a high RUP supplement were treated less for sickness and had decreased feedlot costs, whereas no differences in sickness between steers from dams fed RDP or no protein supplement occurred. This implies certain nutrient or ingredient formulations for range prepartum supplements may positively affect calf health and performance. Reducing the occurrence of sickness and ensuing medical treatments improves feedlot profitability. Galyean (2006) reported calves treated once for disease returned $40.62 less, calves treated twice returned $58.35 less, and calves treated 3 or more times returned $291.93 less compared with calves not treated.

CONCLUSION

Fetal programming and gestational supplementation specifically in beef cows can be a hard task to completely cover in a production system but it is also very important for overall herd health and economic profit. As mentioned many times, grazing dormant range can be a cost effective method of wintering cows but they need extra protein and energy to not have a negative effect on themselves or offspring (Adams et al., 1994). With multiple studies and years being involved, research has shown effective fetal programming can have a positive effect on the future offspring. There is still need for fetal development research, especially in an area like the Nebraska Sandhills where some of the larger cow-calf operations in the United States exist. It also has to be understood most of these studies reported data within one certain time period or study. There is value in using large data sets of fetal programming to further identify the long and short term effects on beef cattle production. The main focus of this programming needs to be on the nutritional status and needs of dams in a production system. Some of this research needs to be focused on long term effects of dam and her offspring both steers and heifers, to better determine how fetal programming effects reproduction of cows, future reproduction of heifers and also longevity in a herd because of fetal programming.

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CHAPTER II

Effects of late gestation supplementation, synchronization, and creep feeding in a spring calving beef herd in the Nebraska Sandhills

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ABSTRACT: A 3-yr study evaluated effects of late-gestation supplementation, postpartum progestin administration, and creep feeding on cow and calf productivity in a spring-calving herd. Crossbred cows (479 ± 57 kg, n = 120) were assigned to 1 of 4 late-gestation supplementation treatments, 1 of 2 postpartum progestin treatments, and 1 of 2 creep feed treatments in a 4×2×2 factorial arrangement of treatments in a completely random design. The 4 supplement (32% CP, 89% TDN) levels were no supplement, 0.41 kg DM/(cow • d) Dec 1 to Mar 1, 0.41 kg DM/(cow • d) Jan 15 to Mar 1, or 0.82 kg DM/(cow • d) Jan 15 to Mar 1. The 2 postpartum progestin treatments were: dministration of exogenous progesterone postpartum via a controlled internal drug release device (CIDR, containing 1.38 g of progesterone) for 7 d and prostaglandin $F_{2\alpha}$ (5 mL Lutalyse) administered on d 7, or no CIDR. Lastly, the 2 treatments for creep feeding were: unrestricted access by the calf to creep feed which contained an intake limiter (Accuration, Purina Animal Nutrition LLC, Gray Summit, MO) or no access to creep feed from July 15 to Nov 1. Any level of late-gestation supplementation increased cow

BW ($P < 0.05$) and BCS ($P < 0.05$) precalving, but did not affect ($P > 0.12$) reproductive measures or calf performance. Exogenous progesterone administration postpartum did not affect ($P > 0.13$) cow or calf performance. Creep feed increased ($P < 0.01$, 250 ± 7 kg) calf BW at weaning by 20 kg. Creep feeding calves tended to increased ($P < .01$) yield grade and significantly increased 12th rib fat ($P < .01$). Final BW and HCW stayed consistent with also being significantly affected ($P > 0.04$). These results differ from previous studies regarding the same type of treatments.

Key Words: beef cattle, creep feed, progesterone, supplementation

INTRODUCTION

Extended grazing to include dormant pasture decreases production costs (Adams et al., 1994). Supplemental RDP has been shown to maintain BCS of gestating cows grazing winter range in the Nebraska Sandhills (Stalker et al., 2007) and feeding supplement to cows grazing winter range during the last trimester of gestation has been shown to increase calf BW at weaning (Stalker et al., 2006; 2007), but it is not known if the timing of supplement feeding optimized progeny performance. Undernutrition during gestation causes suboptimal conditions in the maternal uterine environment, which translate into depressed progeny performance (Wu et al., 2006). Cost savings may be achieved if the amount and duration of supplementation were reduced without adversely affecting progeny performance. Improved efficiency may be achieved if supplement is delivered directly to the calf and could potentially overcome detrimental effects of undernutrition during gestation. Supplementation directly to the calf increases calf-weaning BW (Broadhead et al., 2016), but it is not known if this BW advantage persists at slaughter. A cost/benefit analysis may demonstrate full effectiveness of administering added supplement directly to calf. Other previous research has shown that administration of exogenous progesterone can shorten the postpartum interval to become pregnant sooner (Lamb et al., 2008). This translates to the fact that if weaning occurs on the same d for all calves, those born to cows with a shorter postpartum interval will be older and therefore weigh more than contemporaries born to cows that become pregnant later in the breeding season.

Based on the concepts demonstrated above, the main objectives of this study were to determine effects, amount and timing of late-gestation supplementation, postpartum progestin, and creep feeding on cow and calf productivity in a spring calving herd.

MATERIALS AND METHODS

Animals, Equipment and Factorials

All procedures and facilities were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee (Project 921). A 3-yr experiment utilized 120 crossbred (¾ Red Angus, ¼ Simmental), March-calving multiparous cows (initial BW = 479 ± 57 kg) at the Gudmundsen Sandhills Laboratory, Whitman (lat 42°04′ N, long 101°26′ W, elevation = 1,075 m). Cows were stratified by BW within age. Treatments were assigned randomly in a 4 × 2 × 2 factorial arrangement in a completely random design. The four supplement (32% CP, 89% TDN; Table 2.1) treatments were no supplement (**DM0**), 0.41 kg DM/(cow • d) Dec 1 to Mar 1 (**DM1**), 0.41 kg DM/(cow • d) Jan 15 to Mar 1 (**JM1**), or 0.82 kg DM/(cow • d) Jan 15 to Mar 1 (**JM2**). The 2 postpartum progestin treatments were: administration of exogenous progesterone post-partum via a controlled internal drug release device (EAZI-Breed **CIDR** insert containing

1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for 7 d and prostaglandin $F_{2\alpha}$ (5 mL Lutalyse, Zoetis Inc.) administered on d 7 (**CIDR**), or no progesterone (**NoCIDR**). Lastly, the 2 treatments for creep feeding were: unrestricted access by the calf to creep feed, which contained an intake limiter (Accuration, Purina Animal Nutrition LLC, Gray Summit, MO) from July 15 to Nov 1 (**Creep**) or no access to creep feed (**NoCreep**). Cows were located to 1 of 8 upland range pastures (35 ha) where supplement treatments were delivered on a pasture basis 3 d/wk until March 1. These same pastures were utilized all 3 yr of the experiment. Beginning March 1, cows were managed as a single group and fed ad libitum hay in a dry lot system until the end of calving season. Stalker et al (2007) gives an accurate description of all pastures and available forages at the study location. All studies were conducted on sands range sites (deep sands ecological site) with soils classified as Valentine fine sands (mixed, mesic Typic Ustipsamments). Study pastures were in an area that had been used exclusively for dormant-season (October to March) grazing the previous 8 years and were in good to excellent range condition. Grass species found in the study pastures include little bluestem (Schizachyrium scoparium [Michx.] Nash), prairie sandreed (Calamovilfa longifolia [Hook.] Scribn.), sand bluestem (Andropogon gerardii Vitman var. paucipilus [Nash] Fern.), switchgrass (Panicum virgatum L.), sand lovegrass (Eragrostis trichodes [Nutt.] Wood), scribnerpanicum(Dichanthelium oligosanthes [J. A. Schultes] Gould var. scribnerianum [Nash] Gould), and grasslike plants (Carex spp. and Cyperus spp.) with sun sedge (Carex heliophila Mack.) the most common of these. Common forbs included western ragweed (Ambrosia psilostachya DC.), cutleaf ironplant (Haplopappus spinulosus [Pursh] DC.), and prairie clover (Dalea purpurea Vent.), and shrubs included leadplant

(Amorphacanescens Pursh) and small soapweed (Yucca glauca Nutt.). Common grass species found in subirrigated meadows are smooth brome (Bromus inermus Leyss.), redtop bent (Agrostis gigantean Roth), timothy (Phleum pratense L.), slender wheatgrass (Elymus trachycaulus [Link] Gould ex Shinn.), quackgrass (Elytrigia repens [L.] Nevski.), Kentucky bluegrass (Poa pratensis L.), prairie cordgrass (Spartina pectinata Bosc ex Link), reed grasses (Calamagrostis spp.), and grasslike plants (Carex spp. and Cyperus spp.), rushes (Scirpus spp.), and spikerushes (Eleocharis spp.). Plant nomenclature follows Stubbendieck et al. (1997). Annual herbage production on similar, adjacent pastures averaged 1 260 kg/ ha^{-1} during the study period (Volesky et al. 2005).

At the beginning of breeding, cows were vaccinated against rhinotracheitis (IBR) virus, bovine virus diarrhea (BVD) virus (Types 1 and 2), *Campylobacter fetus* and *Leptospira canicola, L. grippotyphosa, L. hardjo, L. icterohaemorrhagiae*, and *L. pomona* (Vista 3 VL5 SQ, Merck, Kenilworth, NJ). On May 28, CIDR inserts were administered to cows assigned to the CIDR treatment. On June 4, CIDR inserts were removed and cows were administered prostaglandin $F_{2\alpha}$. All cows were exposed to fertile bulls (1:25 bull:cow ratio) for 45 d, with breeding season ending July 20. Cows were managed as one group grazing native upland range until calves were weaned Nov 1.

Cow BW and BCS (Wagner et al., 1988) were measured at the beginning and end of the supplementation period, prebreeding (May 15) and at weaning (Nov 1). Cows received an ivermectin pour-on for internal and external parasites (Promectin B, Vedco, St. Joseph, MO) at prebreeding and weaning. A veterinarian diagnosed pregnancy via rectal palpation at weaning.

Cows were removed from the study for failure to wean a calf or become pregnant. Cows that were removed were not replaced; therefore, the number of cows decreased throughout the 3 yr study (yr 1, n = 120; yr 2, n = 95; yr 3, n = 86; Table 2.3). Additional cows were introduced into pastures only to maintain constant stocking rates during the experiment.

Calf BW was measured at birth, prebreeding, and weaning. Calves received a 7-way clostridial vaccine (Alpha 7, Boehringer/Ingelheim, and Duluth, GA) at birth. All calves received an IBR, BVD Types I and II, PI3, BRSV, Mannheimia haemolytica and Pasteurella multocida (Vista Once SQ, Merck, Kenilworth, NJ) and 7-way clostridial vaccine (Vision 7, Merck, Kenilworth, NJ), and male calves were castrated at branding (May 1).

The non-creep and creep treatment were in separate pastures throughout the 3 yrs. Creep treatment cattle were introduced into pastures containing creep feeders surrounded by panels with 8, 38 cm wide openings sufficient to admit calves, but prevent cow entry. Creep feed was administered for a period of 100 d making it only possible to see an effect on calf weaning BW.

At weaning, all calves (yr 1, n = 35; yr 2, n = 33; yr 3, n = 32) received 2 doses of Vista Once SQ 14 d apart and a 7-way clostridial with somnus (Vision 7 Somnus, Merck, Kenilworth, NJ). Heifer calves were put out on sub irrigated meadow with 0.41 kg DM/(heifer • d) of supplement (32% CP, 89% TDN; Table 2.1). They received a pre-breed shot of Vista 3 VL5 SQ prior to breeding. Steer calves remained in drylot and were fed ad libitum hay for 2 weeks post weaning before being shipped 167 km to a feedlot at the West Central Research and Extension Center, near North Platte, NE. Steer BW was recorded and they received a Synovex Choice (100 mg trenbolone acetate [TBA] and 14 mg estradiol benzoate [EB] implant at the beginning of the feeding period. Steers were weighed and re-implanted with Synovex Plus (200 mg TBA and 24 mg EB) 105 d later (110 prior to harvest). Steers were slaughtered mid-June (Tyson Fresh Meats, Lexington, NE.) Carcass data was collected 24 h following slaughter and final BW was calculated from HCW based on average dressing percentage of 63%. Carcass data measured included HCW, yield grade, LM area, marbling, and 12th rib fat.

Creep Feeding Cost Analysis

Variables utilized for performance and profitability analysis were: distance traveled to administer creep feed, miles per gallon of vehicle utilized, labor costs on a per hr basis, creep feeder equipment cost and depreciation percentage, cost of feed and average market prices within the region and time calves were marketed. Each creep feeder utilized for this study were estimated to originally cost $5,000. Feed costs were calculated based on the cost/ kg of feed and the total DMI of each calf during the creep feeding period. Equipment costs was calculated based on the estimated feeder cost for this trial, a 10 yr depreciation percentage, and the total number of creep-fed calves. Labor costs for the study utilized a $15/h base pay and accounted for the total number of h spent creep feeding through the entire treatment period and the total number of calves receiving creep feed. The labor cost was calculated per calf (Table 2.7). Transportation included the distance traveled to the creep feeder, type of vehicle utilized, the estimated average mpg, and the fuel cost during the study. Market value and prices per animal were obtained from USDA historical prices for the specific time period and location of where calves were marketed (USDA 2015-2017). Total revenue was calculated by multiplying the market value by steer calf HCW at slaughter. Net return for creep feeding was calculated by subtracting the gross income of the no creep calves from the net income of creep fed calves.

Statistical Analysis

Cows assigned to the same winter supplement, CIDR and creep treatment within winter pasture served as the experimental unit, for a total of 16 trt combinations. Replicated treatment means within yr were used for analyses of cow and calf response variables and carcass evaluation. Model fixed effects included winter supplement treatment, CIDR treatment, creep treatment, and all interactions. Year and residual error between treatments were included in the model as random effects. Data were analyzed with the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, NC). Effects of treatment were considered significant when $P < 0.05$ as detected by Fischer's test. A tendency was considered at $P < 0.10$. When the F-test was significant, least square means of treatments were separated using a t-test when $P < 0.05$. There were no interactions ($P > 0.18$) among treatments; therefore, data are reported as main effects. Pregnancy diagnosis was treated as a binomial effect.

RESULTS AND DISCUSSION

Cow Performance

All supplemented groups (DM1, JM1, JM2) increased in BW from beginning of study to calving whereas DM0 decreased BW ($P = 0.06$, Table 2.1). Cows assigned to DM0 treatment had the greatest fluctuation in BW after winter treatment to weaning which could partially be due to gut fill of the cows on this treatment. Even with this difference, they had similar BW at weaning as the beginning of winter treatment. This is most likely due to a compensatory gain. This result agrees with (Stalker et al., 2006) who reported cows receiving protein supplement prepartum had greater BW and BCS precalving and similarly, nonsupplemented cows had greater BW and BCS gain during the postpartum period. The greatest loss in BW occurred between precalving (March) to start of breeding (May) for all 4 treatments. Other than calving BW, cows fed supplement maintained or increased in BW. Differences in BW among supplement treatments were most evident at the beginning of the breeding season where DM0 cows weighed the least ($P < 0.05$), JM1 and JM2 cows intermediate, with DM1 cows having the greatest BW. Cow BCS was lower ($P < 0.05$) at the start of the breeding season for cows not supplemented compared with DM1 and JM2 cows, with JM1 cows being intermediate. Despite decreased BCS over the winter treatment for DM0 and loss in BCS for all groups from calving to breeding, all supplement treatments had similar weaning BCS. Differences in BW and BCS caused by supplementation treatment did not affect measures of reproductive efficiency such as calving date, calving rate, weaning rate, or pregnancy rate ($P > 0.20$, Table 1). Previous research evaluating effects of supplementing cows grazing winter range has demonstrated decreased weaning rate in cows not fed supplement (Stalker et al., 2006), but no effects in other studies (Stalker et al., 2007; Rolfe et al., 2011).

Progestin treatment did not affect ($P > 0.13$, Table 1) BW, BCS, reproductive measures, or calf BW. It is important to consider the pregnancy rates of this study and notice the large difference between DMO and the other supplement groups (78 vs 85+). Reproductive measures may not have been affected due to the fact the herd already had preg rates above 90%. Exogenous progesterone was not expected to affect cow BW or

BCS. Potential increased calf age and therefore, increased weaning BW as a result of earlier conception in the breeding season due to progesterone administration was not realized (P = 0.65). Further research with a herd having below acceptable reproductive performance may be necessary.

Steer Progeny Performance

Supplement treatments did not affect calf birth, breeding, or weaning BW ($P \leq$ 0.80, Table 2.3). Previous research at the same location (Stalker et al., 2006; Stalker et al., 2007; Rolfe et al., 2011) has consistently demonstrated non-supplemented cows grazing winter range wean lighter weight calves. Cow supplementation did not affect steer BW or average daily gain throughout any period of feedlot ($P > 0.24$, Table 2.4). When considering the effect of creep feed, even with the 20 kg difference that held through slaughter, there was only a significant impact on feedlot entry BW ($P < 0.01$) and nothing post feedlot phase. This meant there could be no assumption made that creep feeding attributed to a heavier HCW weight at slaughter. Late gestation supplementation to cows did not affect ($P > 0.51$, Table 1) steer carcass characteristics. Exogenous progesterone was not expected to affect steer carcass characteristics. Although progesterone did have a tendency ($P < 0.10$) to affect calving date within this study which in turn could potentially have some effect on calf weaning BW. Creep feeding calves did not affect ($P > 0.17$, Table 1) HCW, LM area, or marbling. However, creep feeding increased ($P < 0.01$) yield grade and 12th rib fat. Further research with a greater number of observations may be necessary to obtain definitive conclusions about these important characteristics.

Heifer Progeny Performance

Dam supplementation did not affect heifer progeny's age at puberty ($P <$ 0.21, Table 2.5). However, creep feeding tended to ($P < 0.07$) to decrease heifer age at puberty. First and second pregnancy rates were recorded for heifers. Supplement and creep feeding had no effect on first or second pregnancy diagnosis of heifer progeny ($P <$ 0.21). Exogenous progesterone had a tendency to affect first pregnancy diagnosis ($P <$ 0.10) but not the second. There was no interaction interaction of supplement, CIDR and creep feeding, however supplement did tend to affect second pregnancy diagnosis ($P <$ 0.06). Heifer progeny udder score was not affected by any of the treatments ($P < 0.28$). Lastly, when looking at calving vigor, there was a decrease for the calves born to dams on any form of supplementation ($P < 0.05$) but there was no difference between the dam supplementation groups. Calf weaning BW were affected the same for heifers as they were steers as far as the measurements of this study could tell. This is partially due to the fact that heifers were not treated differently within the treatments. Allowing steer and heifer calves access to creep feed increased ($P < 0.01$, Table 1) calf BW at weaning by 20 kg. The total amount of creep that disappeared from the feeder was 1.2 kg DM/(calf • d).

Creep Feeding Performance and Profitability

Creep-fed calves had a heavier weaning BW compared with non-creep calves (P < 0.01, 250 vs 230 ±7 kg, Table 2.7). At slaughter, creep-fed steer calves maintained a 15 kg difference in BW. Creep feeding did not affect ($P < 0.06$) yield grade, LM area, or marbling. Although, creep-fed steers had greater HCW than non-creep steers ($P < 0.04$, 379 vs 367 ± 21 kg), and 12th rib fat ($P < 0.01$, 1.50 vs 1.30 ± 0.08). Creep feed consumption averaged 1.75 kg/d, increasing ADG approximately 0.22 kg (Table 2.8).

Supplement efficiency was 3.83 kg feed per 1 kg gain. On average 1.75kg/(calf • d) of feed disappeared from the creep feeders, attributing to 175 kg/calf. Total amount of feed used over the course of the study was approximately 25,424 kg with a total cost of $6,843, making the average cost/ kg just under $0.13/kg. Creep feed costs averaged $63.49/hd and equipment expenses averaged $10.46/hd. Labor and management costs were estimated to average $16.48/hd. Added transportation to feed was estimated to be $1.44.hd, making the averaged total expense for feeding creep $91.87/hd. Costs for each yr notably varies from about $69 to $110 per head per yr (Table 2.8). Considering market and price slide for calf BW over the study period resulted in a total net loss of $71.05 if calves were sold at weaning. Over the 3 yr, there was an average price slide loss of $83.26/calf. This would be the loss in overall value due to a decrease in the change in size of the animal. On the other hand, the average increase in calf value purely due to weight gain was $97.89/calf. The difference between these 2 averages is the average net effect due to creep feeding, which was $14.63/calf. This value represents the available money to pay for creep feeding, which was far less than the estimated average total costs of $91.87/calf. These average values do hide some of the important differences between each yr. As an example, the first yr had a 0.26 cents difference in market value between the two values, while the last 2 yrs had a 0.10 cents difference. Within this study, increased kg of calf was not offset by cost of creep feed.

IMPLICATIONS

Feeding supplement during winter grazing increased cow BW and BCS, but it did not affect reproduction or calf performance; thus, increasing production costs without increasing returns. Dam supplementation did not affect heifer progeny traits through 2nd

pregnancy diagnosis or steer calf performance through slaughter. These results vary from previous work looking at the effects of supplementation. For this reason, it is important to consider both sides of the results and how added nutrition to dams could negatively or positively affect the outcome to a specific herd. Using a CIDR in cowherds with existing pregnancy rates above 90% may also increase costs without increasing returns. Utilizing CIDRS for synchronization purposes could have much more of an impact on herds with lower pregnancy rates. With this in mind, researching different methods to better a herds reproductive traits can be important. Feeding creep feed to calves is an effective means of increasing weaning BW, carcass yield grade, and 12th rib fat and may impact heifer progeny but should be considered within the context of a cost/benefit analysis, which will be affected by market timing. Within this specific analysis, market price slides have a significant impact on considering whether or not to creep feed calves. Creep feeding will likely not be an economical choice. It should only be considered if the feed can be bought for a much lower price or the F:G ratio is higher. Even with these considerations, there is still the issue of fixed costs with labor, transportation and equipment. Within this study, the benefit of creep feeding was not evident for steer or heifer progeny but there is some evidence from specific results that creep feeding could have an effect on nursing habits, stress on the dam and negative suckling stimulus. These should be considered further when discussing the adverse effects of creep feeding on a beef cow herd.

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Table 2.1 Composition and nutrient analysis of supplement fed to late-gestation, March-calving cows.

Item	DM,%
Ingredient	
Dried distillers grains with solubles	62.0
Wheat middlings	11.0
Cottonseed meal	9.0
Dried corn gluten feed	5.0
Molasses	5.0
Calcium carbonate	3.0
Trace minerals and vitamins[1]	3.0
Urea	2.0
Nutrient	
CP	31.6
Rumen Undegradable intake protein	47.6
TDN	89.4

[1] formulated to include 80 mg/cow daily of monensin

Table 2.2 Effects of winter supplement[1], post-partum progesterone administration[2], and calf access to creep feed[3] on cow productivity

	Supplement				Progesterone		Calf feed			P-Value		
	DM0	DM1	JM1	JM2	CIDR	No CIDR	Creep	No Creep	SE[4]	Supp	Progest	Feed
Cow BW, kg												
Initial (Dec)	479	494	483	479	481	487	482	485	9	0.35	0.37	0.63
Calving (Mar)	446[b]	507[a]	484[ab]	489[a]	482	481	476	487	12	0.06	0.95	0.03
Breeding (May)	434[b]	467[a]	449[ab]	455[ab]	449	453	448	454	9	0.04	0.49	0.34
Weaning (Nov)	480	500	489	487	486	492	492	486	10	0.37	0.41	0.42
Cow BCS[5]												
Initial (Dec)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.1	0.88	0.76	0.81
Calving (Mar)	4.6[b]	5.0[a]	4.9[a]	5.1[a]	5.0	5.0	5.0	5.0	0.1	0.03	0.88	0.76
Breeding (May)	4.5[b]	4.8[a]	4.6[ab]	4.8[ab]	4.6	4.7	4.6	4.7	0.1	0.09	0.62	0.46
Weaning (Nov)	5.3	5.2	5.3	5.4	5.3	5.3	5.3	5.3	0.1	0.75	0.75	0.53
Calving date[6], d	83	86	84	83	83	86	86	83	3	0.79	0.10	0.13
Born in 21 d[7], %	81	74	85	84	82	80	76	86	7	0.45	0.65	0.04
Calving rate[8], %	98	98	99	98	99	97	96	100	3	0.96	0.33	0.08
Weaning rate[9], %	91	95	93	94	91	95	93	93	4	0.71	0.23	0.85
Pregnancy rate[10], %	79	93	93	85	88	87	90	85	7	0.23	0.88	0.11

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 0.41 kg DM/(cow • d) Dec 1 to Mar 1; JM1: 0.41 kg DM/(cow • d) Jan 15 to Mar 1; JM2: 0.82 kg DM/(cow • d) Jan 15 to Mar 1 supplement (32% CP DM).

[2]CIDR: controlled internal drug release device (containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for 7 d and prostaglandin $F_{2\alpha}$ administered on d 7 from May 28 to June 4.

[3]Creep: unrestricted access by the calf to creep feed, which contained an intake limiter from July 15 to Nov 1.

[4]Standard error of the least squares mean (n = 4 observations per treatment replication [**3**/yr]).

[5]Scale of 1 (emaciated) to 9 (extremely obese).

[6]Day of yr calving occurred where January 1 = d 1.

[7]Cows calving within 21 d calculated by finding difference between birth date and breeding date and subtracting from 285.

[8]Calving rate calculated by dividing the number of cows to calve by the number of cows at the beginning of the production yr.

[9]Weaning rate calculated by dividing the number of cows to wean a calf by the number of cows at the beginning of the production yr.

[10]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production yr.

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 2.3 Number of cows removed during 3 yr period

	Supplement[1]			
	DM0	DM1	JM1	JM2
Item				
Start	30	30	30	30
[2]End	12	21	21	16
% of group	60	30	30	46

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 0.41 kg DM/(cow • d) Dec 1 to Mar 1; JM1: 0.41 kg DM/(cow • d)Jan 15 to Mar 1; JM2: 0.82 kg DM/(cow • d) Jan 15 to Mar 1 supplement (32% CP DM).

[2]34 of 50 culled, were culled for pregnancy diagnosis

Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production yr.

Table 2.4 Effects of winter supplement[1], post-partum progesterone administration[2], and calf access to creep feed[3] on heifer and steer progeny productivity pre weaning

	Supplement				Progesterone		Calf feed			P-Value		
	DM0	DM1	JM1	JM2	CIDR	No CIDR	Creep	No Creep	SE[4]	Supp	Progest	Feed
Calf BW, kg												
Birth (Mar)	34	36	34	35	35	35	35	34	1	0.27	0.64	0.16
Breeding (May)	73	74	72	75	74	73	72	75	3	0.75	0.43	0.11
Weaning (Nov)	239	239	239	243	239	241	250	230	7	0.80	0.50	< 0.01

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 0.41 kg DM/(cow • d) Dec 1 to Mar 1; JM1: 0.41 kg DM/(cow • d) Jan 15 to Mar 1; JM2: 0.82 kg DM/(cow • d) Jan 15 to Mar 1 supplement (32% CP DM).

[2]CIDR: controlled internal drug release device (containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for seven d and prostaglandin $F_{2\alpha}$ administered on d 7 from May 28 to June 4.

[3]Creep: unrestricted access by the calf to creep feed, which contained an intake limiter from July 15 to Nov 1.

[4]Standard error of the least squares mean (n = 4 observations per treatment replication [**3**/yr]).

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 2.5 Effects of dam winter supplement[1], dam post-partum progesterone administration[2], and calf access to creep feed[3] on steer progeny growth, feedlot performance, and carcass characteristics

	Supplement				Progesterone		Calf feed			P-Value		
	DM0	DM1	JM1	JM2	CIDR	No CIDR	Creep	No Creep	SE[4]	Supp	Progest	Feed
Item												
Steer BW,kg												
Feedlot entry	240	235	240	250	235	247	253	230	7	0.58	0.09	< 0.01
Final	597	585	565	600	583	591	597	576	15.07	0.27	0.59	0.12
Steer ADG,kg/d												
Overall	1.64	1.66	1.60	1.64	1.66	1.61	1.62	1.65	0.07	0.53	0.14	0.32
Live weight	593	591	577	593	589	589	602	582	14	0.7	1	0.04
HCW, kg	373	372	365	373	372	370	379	367	8	0.73	0.79	0.04
12th rib fat, cm	1.37	1.3	1.37	1.4	1.32	1.4	1.50	1.30	0.03	0.84	0.5	< 0.01
Marbling[11]	439	454	453	448	432	465	474	463	29	0.79	0.03	0.59
LM, cm2	90	90	90	84	90	90	90	90	29	0.75	0.98	0.31
USDA yield grade	2.9	2.9	3	3.2	3	3.1	3.1	2.8	0.2	0.51	0.52	0.06

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 0.41 kg DM/(cow • d) Dec 1 to Mar 1; JM1: 0.41 kg DM/(cow • d) Jan 15 to Mar 1; JM2: 0.82 kg DM/(cow • d) Jan 15 to Mar 1 supplement (32% CP DM).

[2]CIDR: controlled internal drug release device (containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for seven d and prostaglandin F2α administered on d 7 from May 28 to June 4.

[3]Creep: unrestricted access by the calf to creep feed, which contained an intake limiter from July 15 to Nov 1.

[4]Standard error of the least squares mean (n = 4 observations per treatment replication [3/yr]).

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 2.6 Effects of winter supplement[1], post-partum progesterone administration[2], and calf access to creep feed[3] on heifer progeny productivity post weaning

	Supplement				Progesterone		Calf feed			P-Value		
	DM0	DM1	JM1	JM2	CIDR	No CIDR	Creep	No Creep	SE[4]	Supp	Progest	Feed
Calf BW, kg												
Weaning (Nov)	239	239	239	243	239	241	250	230	7	0.80	0.50	< 0.01
Puberty Status[5], %	42	29	54	49	38	49	53	34	2.13	0.05	0.07	0.06
1st Pregnancy rate[6], %	95	79	85	85	87	85	79	93	2.29	<0.01	<0.01	<0.01
Born in 21 d[7], %												
2nd Pregnancy rate[8], %	92	88	93	100	96	91	97	91	1.72	<0.01	<0.01	<0.01

[1]DM0: 0 kg/(cow • d) Dec 1 to Mar 1; DM1: 0.41 kg DM/(cow • d) Dec 1 to Mar 1; JM1: 0.41 kg DM/(cow • d) Jan 15 to Mar 1; JM2: 0.82 kg DM/(cow • d) Jan 15 to Mar 1 supplement (32% CP DM).

[2]CIDR: controlled internal drug release device (containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for 7 d and prostaglandin $F_{2\alpha}$ administered on d 7 from May 28 to June 4.

[3]Creep: unrestricted access by the calf to creep feed, which contained an intake limiter from July 15 to Nov 1.

[4]Standard error of the least squares mean (n = 4 observations per treatment replication [**3**/yr]).

[5]Puberty Status:

[6]1st Pregnancy rate: calculated by dividing the number of heifers determined pregnant by the number of heifers at the beginning of 1st heifer production yr

[7]Born in 21 d: Heifers calving within 21 d calculated by finding difference between birth date and breeding date and subtracting from 285

[8]2nd Pregnancy rate: calculated by dividing the number of heifers determined pregnant by the number of heifers at the beginning of 2nd heifer production yr

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$)

Table 2.7 Effects of creep[1] feeding on steer progeny growth, and profitability

	Creep Feeding			
	Creep	No Creep	SE4	P-Value
Item				
Calf BW, kg				
Weaning(Nov)	250	230		<.001
Creep Feeding Costs				
Feed2, $	63.49			
Equipment3, $/calf	10.46			
Labor4, $/calf	16.48			
Transportation5, $/calf	1.44			
Market Value6, $/kg	2.09	2.25		<.001
Total Revenue7, $/calf	1112	1162		<.001
Net Return of Creep Feed8, $	-41.61			

[1]Creep: unrestricted access by the calf to creep feed, which contained an intake limiter from July 15 to Nov 1.
[2]Feed: Feed cost was calculated by multiplying the cost/kg of feed by the total DMI of each calf
[3]Equipment: Equipment cost was calculated by dividing the feeder cost by a 10 yr depreciation value by the total number of calves fed
[4]Labor: Labor cost was calculated by dividing the total number of hours spent creep feeding by the total number of calves at a $15/hr rate
[5]Transportation: Transportation took in to account the distance traveled to feed, the type of vehicle utilized and avg miles per gallon of that vehicle and the cost of gas during the study
[6]Market Value: USDA prices pulled from time period and location of where steers were slaughtered
[7]Total Revenue: Total Revenue calculated by multiplying market value by calf HCW
[8]Net Return of Creep Feed: Net Return of Creep Feed was calculated by subtracting the gross income of No Creep calves minus the net income of creep feed calves
[9]Standard error of the least squares mean (n = 4 observations per treatment replication [3/yr]).

CHAPTER III

Effects of over winter treatments supplementation treatments on beef cattle cow and calf production traits in the Nebraska Sandhills

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ABSTRACT: Studies were conducted over a 13 yr period at the UNL Gudmundsen Sandhills Laboratory, Whitman, NE. Data were compiled from 4 independent studies that spanned from 2001 to 2016 (*Stalker et al., 2006; Martin et al., 2007; Larson et al., 2008; Funston et al., 2010; Rolfe et al., 2011; Broadhead et al. 2017*).This combined analysis evaluated the effects of late gestation supplementation and weaning periods on cow and calf productivity in a spring calving herd. Among all studies, 712 crossbreed cows (479 ± 57 kg) were assigned to different overwinter treatments and weaning periods the first year. Cows were wintered on dormant range, sub-irrigated meadow, or corn residue with Ruminally Degradable Protein (RDP) supplementation. The 3 supplement (32% CP, 89% TDN) levels were 0, 0.45, or 0.82kg/(cow • d). Weaning differed in each study. The 3 weaning treatments were November, Aug 18 vs Nov 7, or early October vs early December. Steers were transported to a feedlot at the West Central Research and Extension Center, North Platte, NE. Carcass data (HCW, yield grade, LM area, marbling, and 12th rib fat) were collected 24 h following slaughter and final BW was calculated from HCW based on an average dressing percentage of 63%. Each study had different treatments for heifers post weaning. Late gestation supplementation affected pregnancy

rates (*P < 0.01)* regardless of amount or overwinter treatment. Supplementation did not affect cow BW and BCS (*P = 0.18*). Steer calves born to cows fed supplement had greater weaning weights no matter the weaning date (*P < 0.01), while heifer calves had tendency for higher weaning weights (P < 0.07)*.

Key Words: beef cattle, supplementation, pregnancy rate

INTRODUCTION

Grazing dormant pastures in the Nebraska Sandhills reduces production costs by feeding less processed feed. Supplementing the cow can help counteract the rapid growth of the fetus during mid to late gestation by helping to meet the higher metabolic demands of the dam. Research has determined ruminally degradable protein (RDP) is necessary to maintain BCS of gestating beef cows when attempting to extend grazing season. (Adams et al., 1994; Stalker et al., 2007). Undernutrition during gestation causes suboptimal conditions in the maternal uterine environment, which translate into depressed progeny performance (Wu et al., 2006). This depressed performance can have an affect all the way through postnatal performance. Feeding supplement to cows grazing winter range during the last trimester of gestation has been shown to increase calf BW at weaning (Stalker et al., 2006; 2007). Even with increased progeny performance, there has been lack of evidence that late gestation supplementation benefits any cow production traits, including reproduction (Broadhead et al., 2017). This holds true with many fetal programming or supplementation studies (*Stalker et al., 2006; Martin et al., 2007;Larson et al., 2008; Funston et al., 2010; Rolfe et al., 2011;Broadhead et al. 2017)*. It is possible more data points or combined studies of similar treatments may show different results. This demonstrates the importance of looking at a combined analysis vs summarizing prior knowledge in a review. More common than not, research has been summarized in reviews that have value but are lacking statistical evidence of comparing certain studies in the review (Glass, 1976).

When considering statistical power and analysis using multiple data sets can increase the validity of research by increasing the number of data points. There are 2 types of analysis, a meta-analysis that examines or combines data from a number of different sources and independent studies to help determine overall trends. Pooled analysis are used when multiple studies with the same study design and homogeneous populations are used. Authors of review articles often forget observations within a given study will have more in common than observations across studies (St-Pierre, 2001). This knowledge brings about the importance of analyzing large data sets correctly. St- Pierre (2001) indicates the importance of incorporating the study effect and all other interactions as a random statement in a mixed model.

The objective of this study was to determine if a combined analysis would demonstrate actual significant effects from supplementation on cow production traits, including reproduction and similar results for calf production. Based on the individual study results, it was hypothesized this combined analysis would demonstrate different results regarding cow reproduction when more data points are utilized. All other traits were hypothesized to have similar results as individual studies.

MATERIALS AND METHODS

Animals and equipment

All procedures and facilities within every study analyzed, were approved by the University of Nebraska-Lincoln Institutional Animal Care and Use Committee.

Study Site

Studies were conducted over a 13 yr period at the UNL Gudmundsen Sandhills Laboratory, Whitman, NE (lat 42°04′ N, long 101°26′ W, elevation = 1,075 m). Data were compiled from 4 independent studies that spanned from 2001 to 2016 (study references). Stalker et al (2007) gives an accurate description of all pastures and available forages at the study location. All studies were conducted on sands range sites (deep sands ecological site) with soils classified as Valentine fine sands (mixed, mesic Typic Ustipsamments). Study pastures were in an area that had been used exclusively for dormant-season (October to March) grazing the previous 8 years and were in good to excellent range condition. Grass species found in the study pastures include little bluestem (Schizachyrium scoparium [Michx.] Nash), prairie sandreed (Calamovilfa longifolia [Hook.] Scribn.), sand bluestem (Andropogon gerardii Vitman var. paucipilus [Nash] Fern.), switchgrass (Panicum virgatum L.), sand lovegrass (Eragrostis trichodes [Nutt.] Wood), scribnerpanicum(Dichanthelium oligosanthes [J. A. Schultes] Gould var. scribnerianum [Nash] Gould), and grasslike plants (Carex spp. and Cyperus spp.) with sun sedge (Carex heliophila Mack.) the most common of these. Common forbs included western ragweed (Ambrosia psilostachya DC.), cutleaf ironplant (Haplopappus spinulosus [Pursh] DC.), and prairie clover (Dalea purpurea Vent.), and shrubs included leadplant (Amorphacanescens Pursh) and small soapweed (Yucca glauca Nutt.). Common grass species found in subirrigated meadows are smooth brome (Bromus inermus Leyss.), redtop bent (Agrostis gigantean Roth), timothy (Phleum pratense L.), slender wheatgrass (Elymus trachycaulus [Link] Gould ex Shinn.), quackgrass (Elytrigia repens [L.] Nevski.), Kentucky bluegrass (Poa pratensis L.), prairie cordgrass (Spartina pectinata Bosc ex Link), reed grasses (Calamagrostis spp.), and grasslike plants (Carex spp. and Cyperus spp.), rushes (Scirpus spp.), and spikerushes (Eleocharis spp.). Plant nomenclature follows Stubbendieck et al. (1997). Annual herbage production on similar, adjacent pastures averaged 1 260 kg/ ha^{-1} during the study period (Volesky et al. 2005). All studies had similar designs based on the consideration of late gestation supplementation and weaning periods.

Commonalities

Among all studies, 712 crossbreed (¾ Red Angus, ¼ Simmental), March-calving multiparous cows (479 ± 57 kg) were assigned to different overwinter treatments and weaning periods the first year. Cows were wintered on dormant range, sub-irrigated meadow, or corn residue with Ruminally Degradable Protein (RDP) supplementation. The 3 weaning treatments were: 1) Nov, 2) Aug 18 vs Nov 7, 3) or early Oct vs early Dec. The composition and nutrient analysis of the supplement (32% crude protein, 89% total digestible nutrients) used in these studies is listed in Table 3.1. Three levels of supplementation were used: NS (0.00 kg Dry Matter (DM)/(cow • d)), SUP1 (0.45 kg DM/(cow • d)) and SUP2 (0.82 kg DM/(cow • d)).

Cow BW and BCS (Wagner et al., 1988) were measured at the beginning and end of the supplementation period, prebreeding and weaning. Cows received an ivermectin pour-on for internal and external parasites (Promectin B, Vedco, St. Joseph, MO) at prebreeding and weaning. A veterinarian diagnosed pregnancy via rectal palpation at weaning. Within all studies, cows were managed as a single group post treatment period.

Calf BW was measured at birth, prebreeding, and weaning. Calves received a 7-way clostridial vaccine (Alpha 7, Boehringer Ingelheim, Duluth, GA) at birth. Bull calves were castrated and all calves received an IBR, BVD Types I and II, PI3, BRSV, Mannheimia haemolytica and Pasteurella multocida (Vista Once SQ, Merck, Kenilworth, NJ) and 7-way clostridial vaccine (Vision 7, Merck, Kenilworth, NJ) and male calves were castrated at branding (May 1). At weaning, steers received 2 doses of Vista Once SQ 14 d apart and a 7-way clostridial with somnus (Vision 7 Somnus, Merck, Kenilworth, NJ).

Within all studies, steer calves remained in drylot and were offered *ad libitum* hay for 2 wk post weaning before being shipped 167 km to a feedlot at the West Central Research and Extension Center, North Platte, NE. Steers received a Synovex Choice (100 mg trenbolone acetate (TBA) and 14 mg estradiol benzoate (EB)) at the beginning of the feeding period. Steers were re-implanted with Synovex Plus (200 mg TBA and 24 mg EB) 105 d later (110 d prior to harvest). Steers were weighed at feedlot entry and reimplant Steer calves were slaughtered mid-June (Tyson Fresh Meats, Lexington, NE) Carcass data was collected 24 h following slaughter and final BW was calculated from HCW based on average dressing percentage of 63%. Carcass data included HCW, yield grade, LM area, marbling, and 12th rib fat. Heifer management will be listed within each specific study.

Compiled studies

2001-2003 (Stalker et al., 2006; Martin et al., 2007)

A 3 yr study (yr 1, n = 136; yr 2, n = 113; yr 3, n = 113) evaluated the effects of supplemental protein prepartum and grazing subirrigated meadow postpartum on pregnancy rates and calf performance post weaning. This study was arranged in a 2 x 2 factorial and used in a switchback design. Starting Dec 1 through Feb 28, cows assigned to this study grazed dormant upland range in 8 pastures (32 ± 2 ha each). The amount of 0.45 kg DM/ (cow • d) ((32% CP, 89% TDN) was administered to half the cows on a pasture basis 3 d/wk. For 30 d before breeding season (May 1 to May 31). Half of the cows grazed a subirrigated meadow (58 ha), while the other half was fed grass hay in a drylot. Similar to many of the other studies, Cow BW and BCS was monitored and measured throughout each year of treatment and calf performance was measured until slaughter. Heifers utilized in this study were direct progeny of dams referenced above and within this study, dam treatments will be named late gestation (LG) or early lactation (EL) dam nutrition. This was a 3 yr study utilizing 170 heifers looking at the effects of dam treatments on heifer growth and reproduction.

2005-2007 (Larson et al., 2008; Funston et al., 2010)

March-calving cows (yr 1, n = 109; yr 2, n = 114; yr 3, n = 116) grazed range or corn residue over winter. Within grazing treatments, cows received supplement levels of 0.45 kg DM/ (cow • d) ((32% CP, 89% TDN) or no supplement. Postweaning, crossbreed heifer calves (yr 1, n = 56; yr 2, n = 56; yr 3, n = 54) grazed dormant pasture for 114 d and then were individually fed for an 87 d period, before being exposed to fertile bulls (1:25 bull: heifer ratio) for a 45 d breeding season.

2009-2012 (Rolfe et al., 2011)

This study looked atat the long-term effects of weaning date and pre-partum protein supplementation on cow-calf productivity in a spring calving system. All 4 yrs consisted of 144 crossbred beef cows (479 ± 59 kg) utilized in a completely randomized 2x4 factorial arrangement of treatments. These treatments consisted of: 1) cows weaned in early October or early December, and 2) during late gestation cows were supplemented

0.00, 0.41, 0.82 kg DM/(cow • d) ((32% CP, 89% TDN)). All cows were located on dormant winter range or grazed corn residue without supplement.

2014–2016 (Broadhead et al. 2017)

In yr 1 of a 3-yr study, 120 crossbred cows (479 ± 57 kg) were assigned to 1 of 4 late-gestation supplementation treatments, postpartum progestin or control, and 1 of 2 creep feed treatments in a 4×2×2 factorial arrangement of treatments in a completely random design. Supplement levels were 0 kg/(cow • d) Dec 1 to Mar 1, 0.41 kg DM/(cow • d) Dec 1 to Mar 1, 0.41 kg DM/(cow • d) Jan 15 to Mar 1, or 0.82 kg DM/(cow • d) Jan 15 to Mar 1 The 2 postpartum progestin treatments were: administration of exogenous progesterone post-partum via a controlled internal drug release device (EAZI-Breed **CIDR** insert containing 1.38 g of progesterone; Zoetis Inc., Florham Park, NJ) for 7 d and prostaglandin $F_{2\alpha}$ (5 mL Lutalyse, Zoetis Inc.) administered on d 7 (**CIDR**), or no progesterone (**NoCIDR**). Lastly, the 2 treatments for creep feeding were: unrestricted access by the calf to creep feed, which contained an intake limiter (Accuration, Purina Animal Nutrition LLC, Gray Summit, MO) from July 15 to Nov 1 (**Creep**) or no access to creep feed (**NoCreep**).

Statistical Analysis

The individual studies described above were combined into one data set utilizing SAS (SAS Inst., Inc., Cary, NC) since not every treatment within each study was the same. Cows assigned to the same pasture during the treatment periods served as the experimental unit. Replicated treatment means within yr were used for analyses of cow and calf response variables and carcass evaluation. Model fixed effects included winter supplement treatment, weaning period, and all interactions. Year and residual error were included in the model as random effects. Data were analyzed with the GLIMMIX and MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). Effects of treatment were considered significant when $P < 0.05$ as detected by Fischer's test. A tendency was considered at $P < 0.10$. When the F-test was significant, least square means of treatments were separated using a t-test when $P < 0.05$. Data reported differences between treatment means by common superscripts. No interactions were found among treatments; therefore, data are reported as main effects.

RESULTS AND DISCUSSIONS

Cow Performance

Within any amount, supplementation did not affect cow BW or BCS ($P = 0.18$, Table 3.2). This also held true when looking at BW and BCS overall change (P=0.67). These results are contrary to what some of the individual studies demonstrated. With less yr provided, most supplement amounts have shown to increase cow BW. These results demonstrate the importance of feeding supplement during late gestation for cow maintenance rather than gain and that dam supplementation is generally focused on fetal development.

For all studies supplementation to cows during the third trimester of gestation did not affect cow pregnancy rates. Contrary to the studies comprising the analysis, this analysis itself demonstrated any amount of protein supplementation during late gestation did affect pregnancy rates ($P = 0.01$). As demonstrated in Table 3.2, there was no difference between SUP1 and SUP2, with the highest pregnancy rate being 94% from the SUP1 group. Even with the non-supplemented groups still having a 90% pregnancy rate, these results demonstrate the value of supplementing during the last trimester when looking at cow reproduction. These results can also show the importance of BCS and how maintaining a good BCS can affect overall pregnancy rates. Supplementation had no effect on pregnancy rates until we combined all of the data together which also demonstrates part of the statistical reasoning behind combing multiple data sets with similar environments and treatments (St-Pierre., 2001). Combining more data points looking at similar aspects can increase the power of the results the study is attempting to distinguish. Even with the impact on pregnancy rates, further results demonstrated protein supplementation did not affect calving date or the percentage of the herd calving within the first 21d (P = 0.26). It should also be considered that supplementation did not affect some traits because the cows utilized already had high, or sufficient, reproductive performance.

Steer Progeny Performance

Previous research looking at how protein supplementation affected cows on winter range saw progeny weaning BW affected by the level of supplement the dam received (Stalker et al., 2006), while some studies demonstrated no effects (Stalker et al., 2007; Rolfe et al., 2011). Progeny BW is important consideration for any study since BW can translate to more profitability. Within this analysis, protein supplementation provided to the dam affected steer progeny birth (P = 0.02) and weaning BW (P = .001; Table 3.3). This result was expected with the idea that late gestation is the time where fetal size increases the most (Zhu et al., 2004). It also demonstrates the importance of determining proper nutrition requirements of dams in their last trimester of gestation to aid in fetal growth. Once progeny was born steer calves had a higher ADG from birth to weaning when their dams were fed any level of protein supplementation ($P < 0.01$). The NS group had an overall ADG of 0.98 kg/d compared with SUP1 of 1.01 and SUP2 of 1.03 kg/d.

It is also important to determine if added steer size at weaning persisted through slaughter when looking at fetal development (Broadhead et al., 2017). Few carcass characteristics were affected by supplementation. The only characteristic that showed an affect was marbling. The NS groups had an average marbling score of 467 while SUP1 and SUP2 groups had an average score of 487 and 479 respectively ($P = 0.01$). Within the average of these 13 yr of data, supplementation positively impacted back fat. These were similar results compared with the individual results from each study. Live BW for NS groups was 594 kg while SUP1 and SUP2 progeny averaged 591 kg and 593 kg ($P = 0.71$). Supplementation level did not impact ($P \geq 0.58$) HCW, 12th rib fat, LM, or USDA yield grade. As noticed from these results it would be difficult to assume steer progeny would retain added BW at weaning through slaughter. If a producer has this option, these results could be considered on whether or not progeny is being sold at weaning or slaughter weights. Even with added BW not retained at slaughter, these results do not diminish the importance of supplementation to progeny during last trimester of gestation.

Heifer Progeny Performance

Longevity of and reproduction of heifer progeny was an important variable considered in this analysis. There were statistical differences between heifer and steer progeny results. Looking specifically at the effects of supplementation on heifer progeny birth and weaning BW this analysis demonstrated no significant effect on birth BW ($P = 0.27$). The average BW at birth for the NS group was 35 kg while SUP1 and SUP2 demonstrated birth BW of 35 kg and 34 kg respectively. At weaning supplementation showed a tendency to affect BW (P = 0.07) of heifer progeny with NS averaging 220 kg and SUP1 and SUP2 averaging 226 kg and 223 kg per calf. These results translated into supplementation significantly affecting ADG of each group (P <.0001). This affect can show the importance of the fetal development and growth during gestation and how that can translate to progeny growth post birth.

A valuable aspect of all these studies was looking at post weaning performance of all heifer progeny. This analysis showed neither amount of supplementation had a significant impact on puberty status (P = 0.89). These results were consistent with other studies looking at heifer development or longevity. Prebreeding BW and BCS were not affected by any amount of protein supplement to dam throughout this analysis (P = 0.39). These same results held true when considering BCS at pregnancy diagnosis (P = 0.80). Supplementation showed a tendency to affect BW at pregnancy diagnosis (P = 0.09) with NS having an average BW of 375 kg while SUP1 and SUP2 had an average BW of 384 kg for both groups. Pregnancy rate was not affected by supplementation (P = 0.94), with the lowest pregnancy rate being 89% for the SUP1 group and the highest rate being 91% for the SUP2 group. The SUP1 and SUP2 did not have a significant effect on the percentage of calves from the heifer progeny born in the first 21 d of calving. This also held true in consideration of the weaning BW of the calves born to the heifer progeny (P = 0.60). Overall, this analysis demonstrated dam supplementation affects certain stages of heifer BW, but did not affect reproduction measures.

IMPLICATIONS

Within these results, any level of protein RDP supplementation to dams during late gestation will not affect or increase BW or BCS. A lower level of supplementation may be cost effective in helping to maintain these BW and BCS of dams, which may be just as important. Even with no significant difference between the two different amounts of late gestation supplementation, pregnancy rate was affected by proper nutrition utilizing protein supplementation during the last trimester of gestation. Pregnancy rates may be one of the key drivers to supplying late gestation supplementation. Supplementation to dam will have an effect on birth BW of steer progeny and will have a big impact on steer or heifer weaning BW. With this impact, it may be only beneficial to feed a lower level of supplementation compared with the lowest level of supplementation in this study of .45 kg. Any amount of supplementation higher than this may not prove to be cost effective on a cost/benefit analysis. Supplementation may also prove to have a larger impact on progeny growth pre-weaning. Utilizing larger data sets for fetal programming may prove to demonstrate impactful results on cow reproduction and progeny characteristics. These results may also prove the importance of utilizing the correct number of animal units or experiment yr to show more meaningful results.

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TABLES

Table 3.1 Composition and nutrient analysis of supplement[1]

Item	DM,%
Ingredient	
Dried distillers grains with solubles	62.0
Wheat middlings	11.0
Cottonseed meal	9.0
Dried corn gluten feed	5.0
Molasses	5.0
Calcium carbonate	3.0
Trace minerals and vitamins[1]	3.0
Urea	2.0
Nutrient	
CP	31.6
Rumen undegradable intake protein	47.6
TDN	89.4

[1] formulated inclusion of 80 mg/cow daily of monensin

Table 3.2 Effects of late gestation supplementation on cow productivity

	Supplement[1]				
Item	NS	SUP1	SUP2	SE[2]	*P*-Value
Cow BW, Kg					
Initial	494	499	491	12.42	0.18
Weaning	496	500	495	8.60	0.32
BW change	-1.58	-1.78	-3.93	7.94	0.67
Cow BCS[3]					
Initial	5	5	5	0.08	0.23
Weaning	5	5	5	0.05	0.75
BCS change	-0.09	-0.10	-0.12	0.07	0.75
Calving date[4], d	82	83	81	1.85	0.26
Calved in first 21 d[5], %	84	86	85	0.05	0.53
Pregnancy rate[6], %	90[a]	94[b]	93[b]	0.02	0.01

[1]NS = 0 kg/(cow • d); SUP1 = 0.41 kg DM/(cow • d) or 0.41 kg DM/(cow • d); SUP2 = 0.82 kg DM/(cow • d).

[2]Standard error of the least squares mean.

[3]Scale of 1 (emaciated) to 9 (extremely obese).

[4]Day of yr calving occurred where January 1 = d 1.

[5]Cows calving within 21 d was calculated by finding difference between birth date and breeding date and subtracting from 285.

[6]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production yr.

[abc]Within a row, means lacking a common superscript letter differ (P <0.05).

Table 3.3 Effects of late gestation supplementation on steer progeny productivity

	Supplement[1]				
Item	NS	SUP1	SUP2	SE[4]	*P*-Value
Birth BW, Kg	35[a]	36[b]	36[b]	1.2	0.02
Wean BW, Kg	224[a]	229[b]	233[b]	6.28	<0.01
Calf ADG, kg/d					
Birth to Wean	0.98[a]	1.01[b]	1.03[b]	0.04	<0.01
Post weaning performance					
Live weight, kg	594	591	593	5.21	0.71
HCW, kg	374	372	374	5.21	0.71
12th rib fat, cm	1.36	1.35	1.31	0.07	0.58
Marbling[2]	467	487	479	11.78	0.01
LM, cm2	89	88	89	0.00	0.81
USDA yield grade	2.92	2.87	2.89	0.09	0.76

[1]Supplement: NS = 0 kg/(cow • d); SUP1 = 0.41 kg DM/(cow • d) or 0.41 kg DM/(cow • d); SUP2 = 0.82 kg DM/(cow • d).

[2]Marbling: Small^{00} = 400, Small^{50} = 450, Modest^{00} = 500.

[abc]Within a row, means lacking a common superscript letter differ ($P < 0.05$).

Table 3.4 Effects of late gestation supplementation on heifer progeny productivity

	Supplement[1]				
Item	NS	SUP1	SUP2	SEM[2]	P-Value
Birth BW, kg	35	35	34	0.00	0.27
Wean BW, kg	220[a]	226[b]	223[b]	6.69	0.07
Calf ADG, kg/d					
Birth to wean	0.98[a]	1.01[b]	1.03[b]	0.04	<.001
Post Weaning Performance					
Puberty status[3], %	65	64	68	0.65	0.89
Prebreeding BW, kg	336	340	325	26	0.39
Prebreeding BCS[4]	5	5	5	0.10	0.80
Pregnancy diagnosis BW, kg	375	384	384	13.38	0.09
Pregnancy diagnosis BCS	6	6	6	0.04	0.80
Pregnant[5], %	90	89	91	0.67	0.94
Calved in first 21 d[6], %	70	69	79	0.48	0.46
1st calf wean BW, kg	200	197	202	8.55	0.60

[1]Supplement: NS = 0 kg/(cow • d); SUP1 = 0.41 kg DM/(cow • d) or 0.41 kg DM/(cow • d); SUP2 = 0.82 kg DM/(cow • d).

[2]Standard error of the least squares mean.

[3]Puberty Status: Considered pubertal if blood plasma progesterone concentration > 1ng/mL.

[4]Scale of 1 (emaciated) to 9 (extremely obese).

[5]Pregnancy rate calculated by dividing the number of cows determined pregnant by the number of cows at the beginning of the production yr.

[6]Calving within 21 d calculated by finding difference between birth date and breeding date and subtracing from 285.

[abc]Within a row, means lacking a common superscript letter differ (*P* < 0.05).